May 25, 1943.

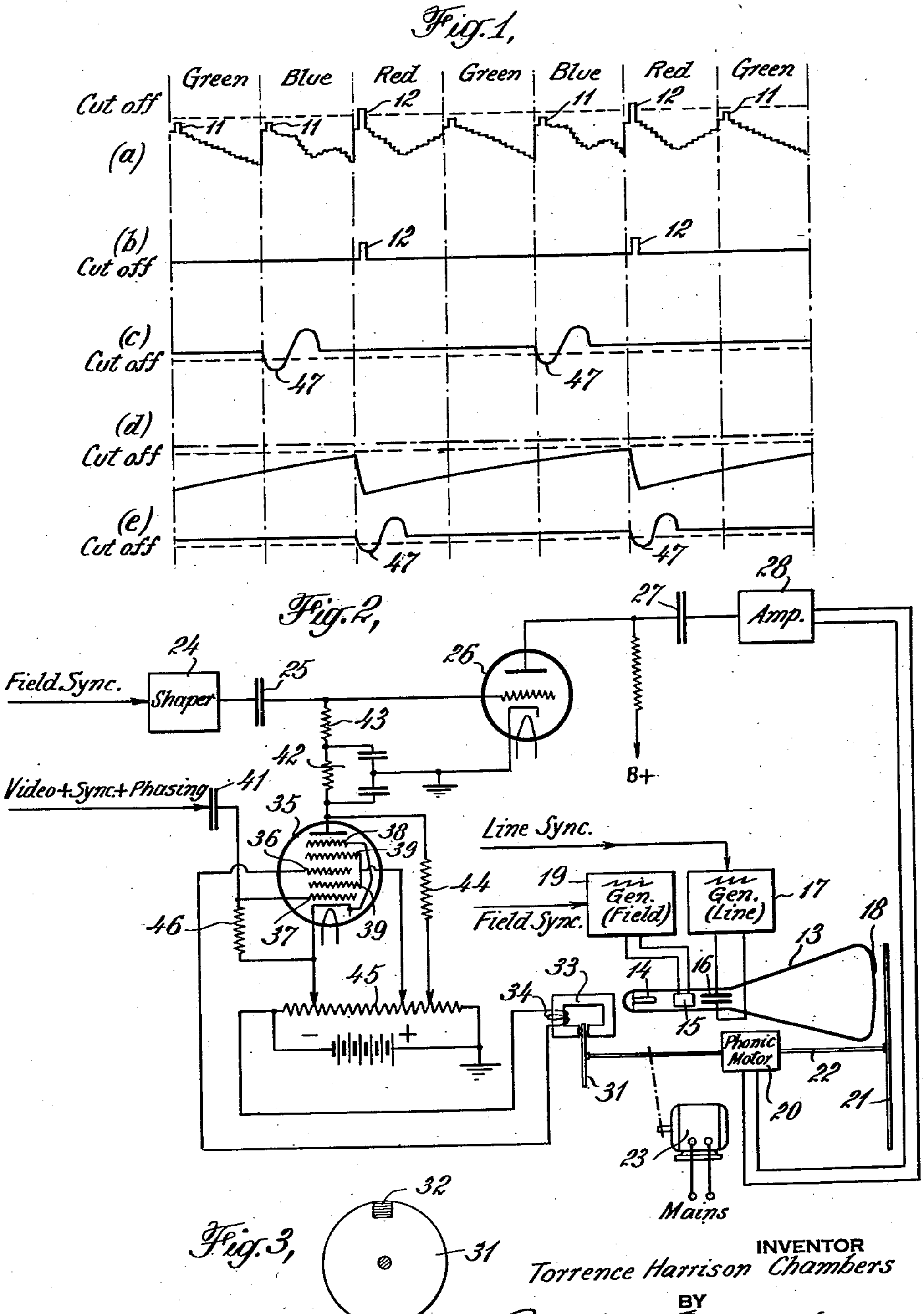
T. H. CHAMBERS

2,319,789

TELEVISION

Filed Oct. 3, 1941

3 Sheets-Sheet 1



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Filed Oct. 3, 1941 3 Sheets-Sheet 2

Fig. 4.

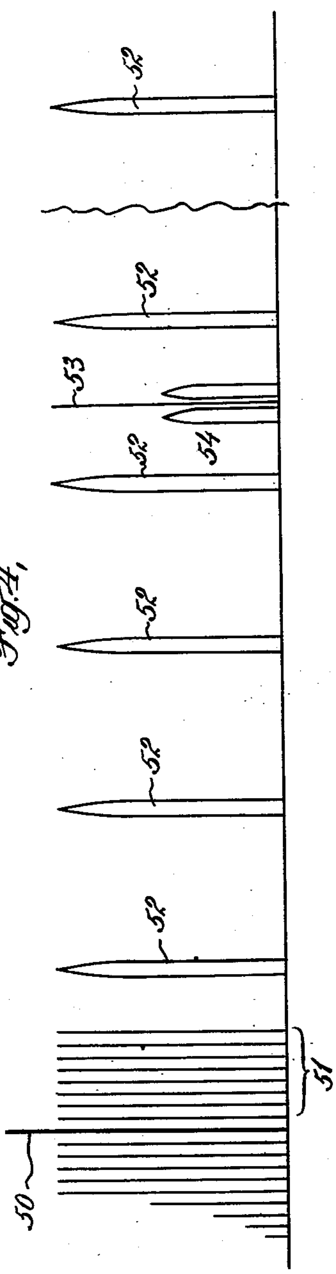
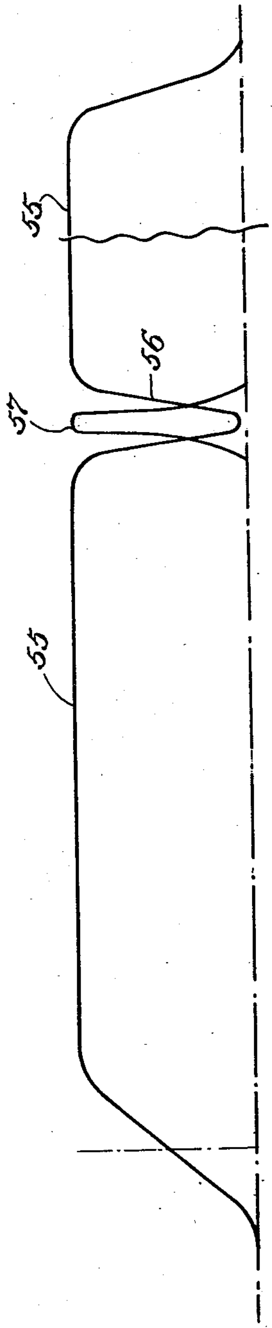


Fig. 5.



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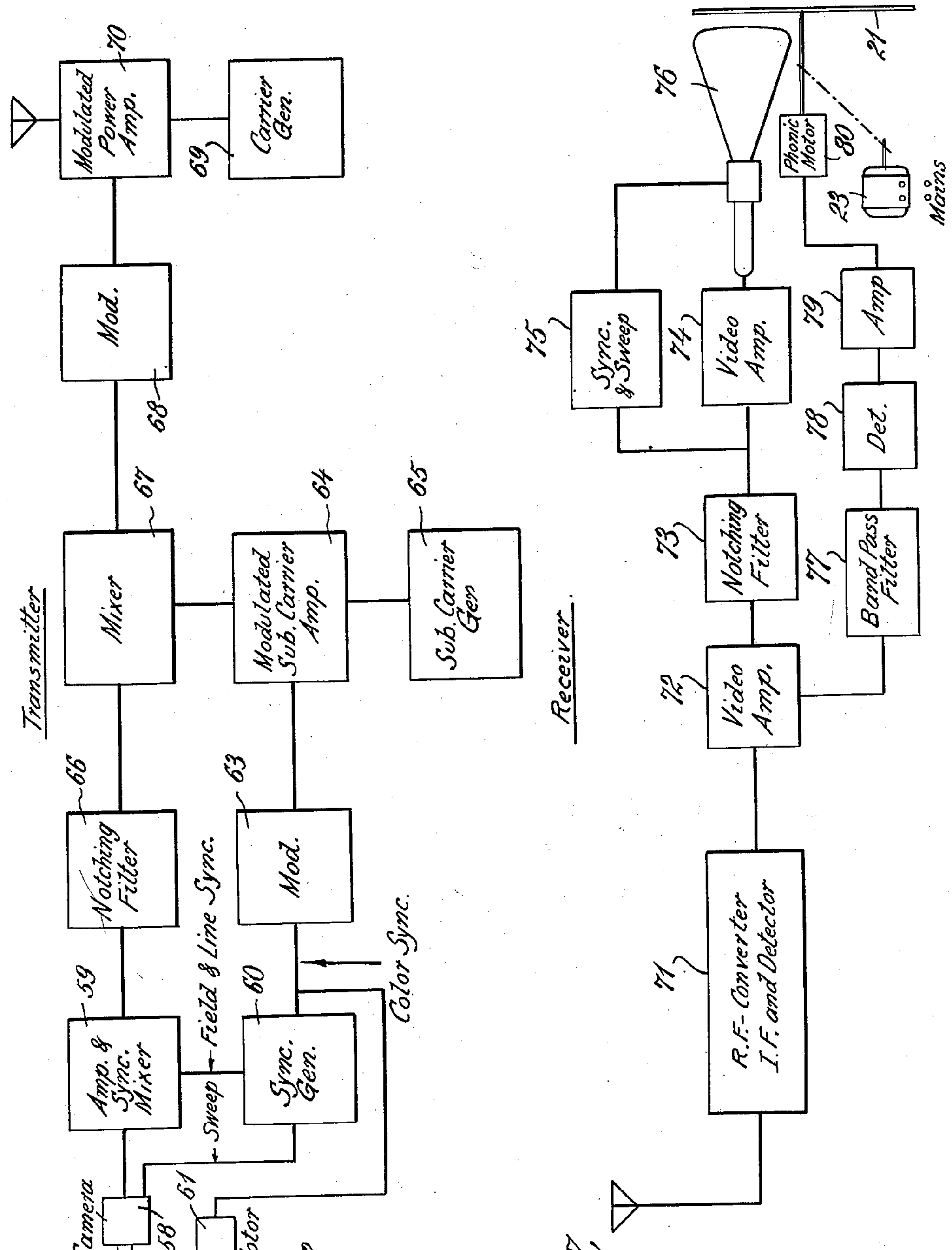

Fig. 6, Fig. 7,

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Patented May 25, 1943 2,319,789

UNITED STATES PATENT OFFICE

2,319,789

TELEVISION

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Application October 3, 1941, Serial No. 413,443

10 Claims. (Cl. 178—5.2)

This invention relates to color television systems, particularly of the type in which images corresponding to different primary colors of an object field are successively transmitted and reproduced.

Color television systems have been suggested in which images representing several primary colors are simultaneously transmitted, and also in which the several images are successively transmitted. The latter system is considered preferable at the present time. In the successive type of system a number of specific scanning procedures have been suggested. In one procedure the entire image field is scanned in one color, say red, then in another color, say green, and then in a third color, blue. In another procedure the image field is scanned in groups of lines, the color changing from one group to the next and provision being made for rotating the colors of the various groups of lines from one field scansion to the next. In another system, which is considered most desirable at the present time, interlaced scanning is employed and successive interlaced field scansions represent different primary colors.

In these systems of successive transmission of different colors, it is necessary that the receiver be so synchronized with the transmitter that at any instant the reproduced image is exhibited in the particular color then being scanned at the transmitter. There have previously been suggested systems in which the transmitter and receiver are so synchronized that the color at the receiver is changed simultaneously with a change at the transmitter, but manual control is relied upon for phasing the receiver so that the images are reproduced in their correct colors.

One such system is disclosed in an application of Peter C. Goldmark, Serial No. 373,713, filed January 9, 1941, for "Television." That application discloses a television receiver employing a cathode-ray tube and a color filter disk having segments of different color spaced therearound and positioned so that as the disk rotates the images on the cathode-ray tube are exhibited successively through different colored segments. The disk is driven by an asynchronous motor energized from the mains and a synchronous motor (for example, a phonic motor) energized under the control of synchronizing pulses so that the filter segments traverse the image area at the frequency of the field scansions. As there explained, when the receiver is first started, although the disk rotates synchronously with the reproduced images, an image corresponding to red may be exhibited through either the red, green, or the blue filter segment. Provision is therefore made for manually changing the phase of the disk with respect to the images so that the images are reproduced in the colors to which they correspond.

It is an object of the present invention to provide a system in which the received images are automatically reproduced in their correct colors. In the specific embodiments hereinafter described, a rotatable color filter element is employed, and the invention provides means for automatically synchronizing the filter element with respect to the reproduced images in correct phase so that the images are exhibited in their correct colors.

In accordance with the invention, color synchronizing signals are transmitted simultaneously with the video signal which has successive portions representing different colors of an object field. Broadly the color synchronizing signals have intervals therebetween equal to an integral multiple of the intervals between successive portions of the video signal representing a selected color of the plurality of colors (the term "multiple" being understood to include one). However, for rapid and reliable operation it is preferred to transmit a signal at each occurrence of the selected color, so that the color synchronizing signals recur at the frequency of a selected color of the plurality of colors transmitted. For example, in three-color television wherein the colors are cyclically scanned for equal intervals, the color synchronizing signals will have a frequency which is one-third that of the plurality of colors. In order to accurately synchronize the receiver, the signals should be definitely related in phase to the portions of the video signal representing the selected color.

In one specific embodiment hereinafter described, the color synchronizing signals are transmitted during the blanking periods before the red signals. However, the color synchronizing signals may be transmitted at other intervals with respect to the video signal, if desired. In another specific embodiment, the signals are impressed on a sub-carrier whose frequency is selected to fall in a vacant region within the video signal spectrum. This has the advantage that the modulated sub-carrier can readily be separated at the receiver without interfering with the ordinary synchronizing of the receiver, and transmitted power is conserved. Furthermore, by selecting the sub-carrier to fall in a vacant region within the video spectrum, the overall frequency band is not extended, thereby permitting the full allotted band to be used to secure high definition, etc.

Broadly, in accordance with the invention these distinctive color synchronizing signals corresponding to a selected color are transmitted and utilized at a receiver to synchronize the reproduction of images in the colors to which they correspond.

When a rotating color filter element, such as a disk, is employed at the receiver, the color synchronizing signals may be used for the sole control of the rotation of the element, by suitably amplifying and shaping the signals or by using the signals to control a local generator for supplying power to drive the element. In such case, assuming that color fields are transmitted at the rate of 120 fields per second, a 40-cycle color synchronizing signal will be employed to control the rotation of the disk. However, since there is unavoidably a certain amount of phase variation of the rotating element with respect to the images, it is advantageous to control the synchronization of the disk at more frequent intervals. Therefore, in accordance with another aspect of the invention, the usual field synchronizing signals may be employed not only to synchronize the reproduction of the images by the scanning device but also to synchronize the rotation of the color filter element so that successive images are presented in successively different colors, and the color synchronizing signals employed to automatically change the phase of the rotating element with respect to the images whenever the images are exhibited through the wrong color filters.

In a specific embodiment described hereinafter the latter operation is effected by locally generating a frequency equal to the frequency at which the filter element exhibits images in the selected color and in substantially fixed phase with the filter element. A departure from correct phase between the color synchronizing signals and the locally generated signals is then utilized to change the phase between the rotating color filter element and the images. In this manner, the higher frequency field synchronizing signals are employed to minimize the phase variation of the color filter element, and the color synchronizing signals are employed to shift the phasing from one color to another until the images are presented in their correct colors.

The invention will be more fully understood by reference to the specific embodiments illustrated in the drawings and the following description thereof.

In the drawings:

Fig. 1 is a diagram illustrating a specific relationship between the color video signal, the color synchronizing signals, and the locally generated phasing signals;

Fig. 2 is a diagram illustrating a specific circuit for utilizing the color synchronizing signals and locally generated phasing signals to automatically present successive images in their correct colors;

Fig. 3 is a detail of a disk used for generating the local phasing signals;

Fig. 4 is a diagram illustrating the position of a modulated sub-carrier in a vacant region of the video spectrum;

Fig. 5 is a diagram illustrating representative receiver response curves for the signals of Fig. 4;

Fig. 6 is a block diagram of a suitable transmitting arrangement for yielding the signals of Fig. 4; and

Fig. 7 is a block diagram of a suitable receiver arrangement for utilizing the signals of Fig. 4.

Referring to Fig. 1*a*, a representative color video signal is illustrated having successive field scansions representing the green, blue and red aspects of the object field. Each field scansion may represent all lines in the object field or, preferably, an interlaced scansion as discussed in the application of Peter C. Goldmark, Serial No. 355,840, filed September 7, 1940, for "Color television." During the blanking intervals before the green and blue fields, the usual field synchronizing signals 11 are transmitted. However, in the blanking periods before the red signals, the usual field synchronizing signal is increased in amplitude as shown at 12. Signals 12 can therefore be used not only for field synchronization but are also distinctive from the signals 11 so that they may be employed as color synchronizing signals.

As is apparent from Fig. 1*a*, the color synchronizing signals 12 recur at a frequency equal to that of one selected color (red) of the plurality of colors transmitted. If desired, the color synchronizing signals may be made distinctive other than by an increase in amplitude. For example, the synchronizing signal for the red fields may be made of the same amplitude as signals 11, but accompanied by a component of a selected frequency, the frequency enabling the signal to be separated at the receiver. Since the average amplitude of such a composite synchronizing signal may be made the same as signals 11, interference with the normal field synchronization at the receiver is minimized. Moreover, instead of transmitting the color synchronizing signals on the same carrier as the video signal, a separate carrier or a sub-carrier could be employed. In any event, it is desirable that the color synchronizing signal be definitely related in phase to the video signal.

It will be understood that the color synchronizing signals can be associated with any color desired. Furthermore, they need not be transmitted during the blanking intervals unless this is necessary to avoid interference with the video signal. As far as correct color phasing is concerned, the signal may be transmitted at any desired point in the field scansion and an appropriate adjustment made in orienting the filter element on its shaft at the receiver.

The color synchronizing signals 12 of Fig. 1*a* may be separated from the remainder of the wave by clipper circuits such as are well known in the art. For example, the entire wave may be applied in sufficient amplitude to self-bias a tube in such manner as to cut off all portions of the wave below the dotted line of Fig. 1*a*. This will yield in effect the color synchronizing signals shown in Fig. 1*b*.

A consideration of Figs. 1*c*, 1*d* and 1*e* will be deferred until Fig. 2 has been described.

Referring to Fig. 2, a cathode-ray receiver tube 13 is shown, provided with the usual electron gun 14, vertical deflecting plates 15 and horizontal deflecting plates 16. It will of course be understood that deflecting coils may be employed instead of deflecting plates. The horizontal deflecting plates 16 are energized by a suitable saw-tooth wave generator 17 under the control of line synchronizing signals for producing line scansion of the fluorescent screen 18 of the tube. Vertical deflecting plates 15 are energized by a suitable saw-tooth wave generator 19 of field scanning frequency, under the control of the field synchronizing signals. Successive image fields are thereby reproduced on substantially the same area of the reproducing luminescent surface 18.

A color filter disk 21 is mounted on axis 22, and positioned to rotate in front of the cathode-ray receiver tube. The disk is provided with color filter segments spaced therearound so that as the disk rotates the image area 18 of the tube is successively exhibited through filters of different color. The disk is driven by an asynchronous motor 23 of suitable type, energized from the mains. This motor supplies most or all of the driving power for the disk. An auxiliary synchronizing device, here shown as a phonic motor 20, is employed to obtain synchronous rotation. It is preferred to design the asynchronous motor and its coupling so that it tends to drive the disk somewhat above synchronous speed, and employ the phonic motor to act as a brake.

Phonic motor 20 is energized under the control of the field synchronizing signals. As here specifically illustrated, the field synchronizing signals are passed through a shaper 24 to obtain approximately a sine wave, and this wave is supplied through coupling condenser 25 to the grid of a thermionic vacuum tube 26. The plate circuit of tube 26 is coupled through condenser 27 to a power amplifier 28 which supplies current to motor 20. The design of the motor and the number of filter segments on disk 21 is selected so that filter segments traverse the image area of tube 13 at field frequency. The position of the disk on its shaft is initially adjusted so that when the motor is energized under the control of the synchronizing field signals, the segments are in proper phase with the successively reproduced images.

Prior to each operation of the receiver, the color disk 21 has a random phase relationship with the scanning tube and hence, although the field synchronizing signals will insure that the segments of the disk traverse the image area in synchronism and proper phase with respect to the images reproduced, the particular segment traversing the image field during a given field scansion may not be the correct color for the image then being reproduced. In order to automatically insure that the color of the segment will correspond to that of the image being reproduced, a local phasing signal generator is mounted on shaft 22. This generator may comprise a disk 31 of non-magnetic material such as brass, having a slug 32 (Fig. 3) of magnetic material such as iron mounted on the periphery thereof. The disk 31 is mounted to pass through a gap in an iron core 33 which is encircled by winding 34. Thus, when the slug passes through the gap in the iron core, a signal of the form shown in Fig. 1c is generated in the winding.

When the color filter disk 21 has only three differently colored segments, only one slug 32 is employed on the generating disk 31. With six segments comprising two sets of filter segments, two slugs at diametrically opposite points may be employed, and similarly for a greater number of filter segments. Since the local generator is mounted on the same shaft as the filter disk, the resulting signals will have the same frequency as that at which a segment of given color traverses the image area of the cathode-ray tube, and the signal will have a definite phase relationship with respect to the traversal of the image area by the segment of given color. It will be understood that the local generator specifically described is by way of example only, and other forms of generator can be employed if desired. Also, although direct coupling is advantageous, indirect coupling may be employed if desired.

If for any reason it is desired to employ color synchronizing signals recurring at, say, every second field, every third field, etc., of a given color, the generator may be designed to yield local signals of the same intervals when the disk is rotating at synchronous speed.

In Fig. 2, the locally generated phasing signals and the transmitted and received color synchronizing signals are employed to control the supply of current to phonic motor 20. When the two signals are in correct phase relationship, the supply of current to motor 20 is uninterrupted. When the signals are out of correct phase, the supply of current is cut off, thereby permitting the filter disk 21 to drift asynchronously until the two signals are in phase, whereupon current is restored.

To effect this operation, a phase-comparing circuit having a thermionic vacuum tube 35 of the pentagrid mixer type may be employed. This tube has two control grids 36 and 37, a suppressor grid 38 connected to the cathode, and screen grids 39 connected to a suitable potential.

The winding 34 of the local generator is connected to control grid 36 and the received color synchronizing signals are supplied to control grid 37. The plate circuit of tube 35 is connected through a time-delay circuit 42 and grid resistance 43 to the control grid of tube 26, the connections being such that when the two signals on the control grids 36 and 37 are in phase, no plate current flows in tube 35, bias is normal on tube 26 and the supply of energizing current to the phonic motor 20 is undisturbed. On the other hand, when the two signals supplied to grids 36 and 37 are out of phase, sufficient plate current flows through tube 35 to bias the grid of tube 26 beyond cut off, thereby interrupting the supply of current to motor 20.

Describing the circuit in more detail, since the plate circuit of tube 35 is direct connected to the grid circuit of tube 26, the plate of tube 35 is operated at a slight negative potential with respect to ground, so as to provide a suitable bias for the grid of tube 26, and the cathode of tube 35 is operated at a larger negative potential to ground. Thus, the plate of tube 35 is connected through the plate resistance 44 to a suitable point on the voltage divider 45 to provide a negative bias for the grid of tube 26. The plate of tube 35 is also connected to the grid resistance 43 of tube 26 through the time-delay or integrating network 42.

The complete received signal comprising video, field synchronizing and color synchronizing signals of Fig. 1*a* is supplied through the condenser 41 to the control grid 37 of tube 35. This control grid is returned to the cathode through a relatively high resistance 46. Condenser 41 and resistance 46 are designed to function together with grid 37 of tube 35 in a manner well-known in the art as a clipper circuit, so that grid 37 is biased beyond cut-off at all times except when the color synchronizing signals occur. The effective result is illustrated in Fig. 1*b*. One end of the coil 34 of the local generator is connected to control grid 36 and the other end is connected to the voltage divider 45 at a point slightly negative to that of the cathode but above cut-off. This negative bias is selected with respect to the voltage generated by the local generator so that the grid **36** is normally above cut-off, but is driven below cut-off by negative pulses produced by the local generator. This relationship is illustrated in Fig. 1*c* where the dotted line indicates the cut-off point of grid **36** and the negative portion **47** of the locally generated pulses drive the control grid below cut-off. Screen grids **39** are connected to the voltage divider **45** at a point of suitable potential for example slightly below plate potential.

The operation of the apparatus of Fig. 2 will now be described. It will be assumed that when the apparatus has been started and the driving asynchronous motor **23** has brought the speed of the disk up to approximately synchronous speed, the disk is so phased wtih respect to the successively reproduced images that the red filter is in front of the tube when an image corresponding to blue is being reproduced. The pulses effective at the control grids **37** and **36** for this condition are shown in Figs. 1*b* and 1*c*, respectively. It will be noted that the locally generated pulses **47** are out of phase with the incoming color synchronizing pulses **12** so that when pulses **12** drive control grid **37** above cut-off, grid **36** is also above cut-off and tube **35** passes plate current. The flow of plate current through plate resistance **44** reduces the potential of the plate and acts through the time delay or integrating circuit **42** to bias the grid of tube **26** below cut-off. The plate current of tube **35** will flow only for the duration of the color synchronizing pulse **12**, but the integrating circuit **42** maintains the grid of tube **26** beyond cut-off until the next pulse comes along. This effect is shown in Fig. 1*d* which represents the bias on the grid of tube **26** when the color synchronizing signals of Fig. 1*b* are out of phase with the locally generated phasing pulses of Fig. 1*c*. No current will be supplied to the phonic motor and hence the asychronous speed at which motor **23** drives disk **21** will cause the disk to drift with respect to the successive images until the image representing red is exhibited through the red filter.

When this correct color phasing occurs, the locally generated phasing signals **47** will be in phase with the received color synchronizing signals **12** as shown in Figs. 1*b* and 1*e*. Under these conditions, when the color synchronizing signals **12** drive grid **37** above cut-off, the negative local phasing signals **47** drive grid **36** below cut-off and no plate current flows in tube **35**. The constants of the delay circuit **42** are selected so that the negative voltage previously impressed upon the grid of tube **26** will be dissipated in an interval slightly greater than that between pulses **12**, so that the grid of tube **26** is allowed to go above cut-off, thereby energizing the phonic motor under control of the field synchronizing pulses. Thereafter, the disk will be maintained in proper synchronization with the successive images by the field synchronizing signals so that the images are correctly reproduced in the colors to which they correspond.

It is advantageous to make the negative portions **47** of the locally generated phasing signals considerably wider than the incoming color synchronizing pulses **12** so that the phase between the signals of Figs. 1*b* and 1*c* can vary through a considerable angle without cutting off the supply of synchronizing current to the phonic motor. Indeed, the width of negative pulses **47** can be made as large as one-half a field period if desired. The advantage is that when the disk is running asynchronously and momentarily is in correct color phase, thereby allowing the flow of synchronizing current to the phonic motor, a certain interval elapses before continued asynchronous rotation can cause the synchronizing current to be cut off. This interval may be selected to permit the phonic motor to overcome the inertia of the disk, etc., as well as the driving force of the motor **23** if that motor tends to drive the disk overspeed, and effect synchronous rotation in proper color phase. The width of pulses **47** necessary to provide an interval during which the phonic motor can effect synchronization will of course depend on the inertia of the rotating system, the power of the phonic motor and the power of the asynchronous motor, etc.

It will be observed, however, that even though the width of pulses **47** allows a desirable phase variation for effecting color synchronization, it does not adversely affect the accuracy with which the segments are phased with their respective images once correct color synchronization is obtained. When this condition is reached, full control of synchronization is given to the field synchronizing signals acting through shaper **24**, tube **26** and power amplifier **28** to energize the phonic motor. The latter synchronizing channel can be designed to hold the phase between successive segments and their respective images between very small limits.

Ordinarily, it is considered desirable to have the asynchronous motor **23** tend to drive the filter disk **21** slightly above synchronous speed, so that the phonic motor acts as a brake. However, it is possible to design the apparatus so that the asynchronous motor tends to drive the disk somewhat under speed, in which case the phonic motor may be designed to bring the disk up to synchronous speed. Also, instead of using a phonic motor as a brake, other types of brakes may be employed if desired. Instead of using the field synchronizing signals directly to control the energization of the phonic motor or other form of brake, the field scanning saw-tooth wave may be employed. In such case, the field synchronizing signals indirectly control the energization inasmuch as they are employed to control the synchronous production of the field scanning saw-tooth wave.

It will, of course, be understood that instead of applying the entire received signal to the control grid **37** of tube **35** and employing a clipper circuit, the color synchronizing signals **12** may be separated from the remainder of the signal in a previous stage and only the color synchronizing signals applied to grid **37**. In particular, when the color synchronizing signals are made distinctive in frequency rather than in amplitude such a system would be employed, the color synchronizing signals being separated in a frequency separating stage and the resulting signals applied to the grid **37**.

It will be noted that tube **35** and its associated circuits function as a phase-comparing circuit to compare the phase of the incoming color synchronizing signals **12** with the phase of the locally generated signals **47**, the phase-comparing circuit functioning to alter the speed at which the driving means drives the filter disk when the signals are out of phase.

As will be understood by those skilled in the art, different forms of phase-comparing circuits may be employed, and the specific manner in which a change in phase effects control may be changed, if desired. In general, the manner of effecting control should be adapted to the specific synchronizing device used to synchronize the rotation of the disk, so as to provide the proper energizing current.

As previously mentioned, the color synchronizing signals may be impressed on a sub-carrier whose frequency lies in a vacant region within the spectrum of the video signal.

Fig. 4 is a diagram illustrating in a general manner the frequency spectrum of a video signal. From the mathematics of scanning it is found that below line frequency all information in the video signal is at integral multiples of the field frequency, and above line frequency all information is concentrated around multiples of the line frequency in groups of frequencies which differ from the multiple frequency by small multiples of the field frequency. This is indicated in Fig. 4 where the band 51 includes a group of frequencies which are multiples of the field frequency, and the bands 52 represent bands concentrated around multiples of the line frequency, each band 52 including a number of frequencies differing by small multiples of the field frequency. The carrier is indicated at 50.

It will be seen that there are a number of vacant regions in the spectrum. By putting a sub-carrier 53 in one of these vacant regions and modulating the sub-carrier by the color synchronizing signals represented by side bands 54, the color synchronizing signals may be transmitted in a single channel (e. g., on the same carrier) without increasing the band width required.

It will be understood that in Fig. 4 no attempt has been made to show the relative magnitudes of the various frequency components, since they will differ with the character of the picture. It will also be understood that no effect has been made to accurately reproduce the number and position of frequency bands since there are several hundred bands in the normal picture. The exact position of the sub-carrier should be chosen so that the side bands 54 as well as the carrier 53 itself fall within the vacant region.

While in the specific illustration used here double sideband transmission is used with the sub-carrier and vestigial sideband transmission is used with the main carrier, it is to be understood that any sideband transmission characteristic may be substituted in either case or if desired frequency modulation with any desired deviation ratio (including ratios less than unity) may be used on either carrier.

Fig. 5 represents a somewhat idealized receiver band pass. The curve 55 represents a response curve for the signal which is applied to the grid of the cathode ray receiver tube and is "notched" at 56 by a suitable filter circuit to eliminate the sub-carrier 53 and its associated side bands 54. It will be noted that notching the band in this region does not cut out any of the video signal. A separate band pass channel 57 may be provided at the receiver with a suitable filter circuit to pass only the sub-carrier and its side bands.

Any desired means may be employed at the transmitter for introducing the sub-carrier and its side bands into the proper part of the video signal spectrum. Fig. 6 illustrates diagrammatically one way in which this can be done. The video signal from camera 58 is supplied to the usual amplifier and synchronizing signal mixer 59. Mixer 59 is also supplied with the usual line and field synchronizing signals from generator 60. Generator 60 also furnishes color synchronizing signals for controlling motor 61 which drives the color filter disk 62. The color synchronizing signals are supplied to modulator 63 and thence to the modulated sub-carrier amplifier 64, which is supplied with the sub-carrier frequency from generator 65. The video signal from mixer 59 may be passed through a notching filter 66 which is designed to prevent the passage of frequencies in the region of the sub-carrier. It will be appreciated that theoretically no notching filter is necessary at this point since the video signal does not contain intelligence of the selected sub-carrier frequency. However, the notching filter may be employed if desired in order to positively cut out any spurious signals. The modulated sub-carrier and the video signal are supplied to mixer 67 and thence to the modulator 68. The output of modulator 68 and the carrier frequency from generator 69 are supplied to the modulated power amplifier 70 and thence transmitted.

Referring to Fig. 7, a representative diagram of a receiver is shown. The incoming signals are passed through R. F., converter, I. F. and detector stages, represented by the block 71. The output of these stages is supplied to a video amplifier 72. The output of the video amplifier is passed into two channels. One chanel contains a notching filter 73 designed to cut out the sub-carrier 53 and its side bands 54, so as to yield the video signal channel 55 (Fig. 5). The video signal is then supplied through a video amplifier 74 and synchronizing and sweep circuits 75 to the cathode ray receiver tube 76. The other channel contains a band pass filter 77 whose band pass characteristic is represented by 57 (Fig. 5), and is designed to pass only the sub-carrier channel 53 and its side bands 54. The output is then passed into the detector 78 to demodulate the modulated sub-carrier and obtain the color synchronizing signals, the signals being then passed through amplifier 79 and used to directly energize the phonic motor 80.

The color disk 21 is driven by an asynchronous motor 23 energized from the mains and the phonic motor 80 maintains the disk in proper color synchronization with the successive images reproduced by tube 76, so that each image is exhibited in the color to which it corresponds.

It will be noted that in the system of Figs. 4–7 the synchronization of the color filter disk is positively controlled by the color synchronizing signals, since they are used to directly control the energization of the phonic motor at all times. For example, in 3-color television with 120 color fields per second, the color synchronizing signals will be 40 per second and the energizing current for the phonic motor 80 will be 40 cycles per second. In the system of Fig. 2 the control may be said to be negative, that is, the control is exercised only when the filter disk is out of correct color phase with the reproduced images.

The system of Figs. 4–7 wherein the color synchronizing signals are transmitted on a sub-carrier in a vacant region within the video spectrum may be used with the synchronizing system of Fig. 2, the separated signals from amplifier 79 (Fig. 7) being supplied to grid 37 of tube 35 (Fig. 2). It may also be used to transmit related signals other than color synchronizing signals, if desired.

It will be understood that many variations of the specific embodiments described herein may be devised. Therefore, it will be understood that the present invention is not limited to the mere details of design, construction and arrangement of the elements disclosed, since many modifications may be made by those skilled in the art without departing from the spirit and scope of the invention.

I claim:

1. In a color television system, the method which comprises generating a color video signal having successive portions representing different colors of a selected plurality of colors and corresponding image synchronizing signals, generating a sub-carrier of a frequency lying in a vacant region within the spectrum of said video signal and impressing thereon modulating color synchronizing signals of the frequency of portions representing a selected color of said plurality of colors, transmitting said color video and image synchronizing signals and the modulated sub-carrier on a carrier of selected frequency, receiving, demodulating and utilizing said video and image synchronizing signals for reproducing images corresponding to successive portions of the video signal, and receiving, demodulating and utilizing said color synchronizing signals for synchronizing the reproduction of said images in the colors to which the images correspond.

2. In a color television system, the method which comprises generating a color video signal having successive portions representing successive field scansions in different colors of a cyclically recurring plurality of primary colors, generating field synchronizing signals in the blanking intervals between successive field scansions, generating a sub-carrier of a frequency lying in a vacant region within the spectrum of said video signal and modulating the sub-carrier with color synchronizing signals of the frequency of successive field scansions representing a selected primary color, transmitting said color video and field synchronizing signals and the modulated sub-carrier on a carrier of selected frequency, receiving said modulated carrier and separating the modulated sub-carrier from the video and field synchronizing signals, utilizing the received video and field synchronizing signals for reproducing images corresponding to successive field scansions, and demodulating the modulated sub-carrier and utilizing said color synchronizing signals for synchronizing the reproduction of said images in the colors to which the images correspond.

3. In television transmission, the method which comprises generating a video signal, simultaneously generating a sub-carrier having a frequency lying in a vacant region within the spectrum of said video signal, modulating said sub-carrier with synchronizing signals for said video signal, modulating a carrier with said video signal and modulated sub-carrier, and transmitting said carrier as so modulated.

4. In a television transmitter, the combination which comprises means for generating a video signal, means for generating synchronizing signals for controlling the reproduction of said video signal, a sub-carrier generator for generating a sub-carrier of a frequency lying in a vacant region within the spectrum of said video signal, means for modulating said sub-carrier with said synchronizing signals, means for generating a carrier and modulating the carrier with said video signal and modulated sub-carrier, and means for transmitting the carrier as so modulated.

5. In a color television transmitter, the combination which comprises means for generating a color video signal having successive portions representing successive field scansions in different colors of a cyclically recurring plurality of primary colors, means for generating field synchronizing signals in the blanking intervals between successive field scansions, means for generating color synchronizing signals of the frequency of successive field scansions representing a selected primary color, a sub-carrier generator for generating a sub-carrier of a frequency lying in a vacant region within the spectrum of said video signal, means for modulating said sub-carrier with said color synchronizing signals, means for generating a carrier and modulating the carrier with said video and field synchronizing signals and with the modulated sub-carrier, and means for transmitting the carrier as so modulated.

6. In a natural color television receiver adapted to receive a video signal having successive portions representing successive field scansions in different colors of a cyclically recurring plurality of primary colors and accompanying field synchronizing signals of field scanning frequency and distinctive color synchronizing signals having intervals therebetween equal to an integral multiple of the intervals between successive field scansions of a selected color, the improvement which comprises means for reproducing images from said video signal, a rotating color filter element adapted to exhibit images in successively different colors, means responsive to the first-mentioned synchronizing signals for synchronizing said reproducing means to reproduce successive images corresponding to successive field scansions and for synchronizing said rotating color filter element to exhibit successive field images in different primary colors, means for locally generating phasing signals having intervals therebetween equal to a multiple of the intervals at which said rotatable color filter element exhibits images in said selected color and in substantially fixed phase with said element, and means responsive to a departure from correct phase between said color synchronizing signals and said local phasing signals to change the phase between said rotating color filter element and said images to thereby exhibit said images in the colors to which the images correspond.

7. In a natural color television receiver adapted to receive a video signal having successive portions representing successive field scansions in different colors of a cyclically recurring plurality of primary colors and accompanying field synchronizing signals of field scanning frequency and distinctive color synchronizing signals of the frequency of a selected color, the improvement which comprises means for reproducing images from said video signal, a rotating color filter element adapted to exhibit images in successively different colors, means responsive to the first-mentioned synchronizing signals for synchronizing said reproducing means to reproduce successive images corresponding to successive field scansions and for synchronizing said rotating color filter element to exhibit successive field images in different primary colors, means for locally generating phasing signals of the frequency at which said rotatable color filter element exhibits images in said selected color and in substantially fixed phase with said element, and means responsive to a departure from correct phase between said color synchronizing signals and said local phasing signals to change the phase between said rotating color filter element and said images to thereby exhibit said images in the colors to which the images correspond.

8. In a natural color television receiver adapted to receive a video signal having successive portions representing successive field scansions in different colors of a cyclically recurring plurality of primary colors and accompanying field synchronizing signals of field scanning frequency and distinctive color synchronizing signals of the frequency of a selected color, the improvement which comprises a scanning device for reproducing images from said video signal, synchronizing means associated with said scanning device and responsive to said field synchronizing signals to reproduce images corresponding to successive field scansions on substantially the same area of the scanning device, a rotatable color filter element having filter segments arranged therearound and positioned to exhibit said area in successively different primary colors as the element rotates, driving means for said filter element, color filter synchronizing means responsive to said field synchronizing signals for controlling said driving means to exhibit successive field images in different primary colors, a generator associated with said filter element for generating color phasing signals of the frequency at which images are exhibited in a selected color by said filter element and in substantially fixed phase with the filter element, and a phase-comparing circuit responsive to said color synchronizing signals and the locally generated color phasing signals for altering the speed at which said driving means drives the filter element when said signals are out of phase to thereby present images in the colors to which the images correspond.

9. In a natural color television receiver adapted to receive a video signal having successive portions representing successive field scansions in different colors of a cyclically recurring plurality of primary colors and accompanying field synchronizing signals of field scanning frequency and distinctive color synchronizing signals of the frequency of a selected primary color, the improvement which comprises a scanning device for reproducing images from said video signal, synchronizing means associated with said scanning device and responsive to said field synchronizing signals to reproduce images corresponding to successive field scansions on substantially the same area of the scanning device, a rotatable color filter element having filter segments arranged therearound and positioned to exhibit said area in successively different primary colors as the element rotates, an asynchronous motor coupled to drive said filter element, a synchronizing device coupled to said filter element and responsive to energization to change the speed at which the synchronous motor tends to drive the filter element, a source of energizing current for said synchronizing device controlled by said field synchronizing signals to cause said filter element to rotate synchronously to exhibit successive field images in successive primary colors, a generator associated with said filter element for generating color phasing signals of the frequency at which images are exhibited in a selected color by said filter element and in substantially fixed phase with the filter element, and a phase-comparing circuit responsive to said color synchronizing signals and the locally generated color phasing signals for changing the energization of said synchronizing device when said signals are out of correct phase to thereby alter the speed of rotation of the filter element and secure correct phase, said color filter element being oriented to exhibit images in the colors to which they correspond when said correct phase obtains.

10. In television transmission, the method which comprises generating a video signal, simultaneously generating a sub-carrier having a frequency lying in a vacant region within the spectrum of said video signal, modulating said sub-carrier with signals related to said video signal, and transmitting said video signal and modulated sub-carrier on a single channel.

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